Pacific Northwest NATIONAL LABORATORY

King County METRO

2nd Life Test Protocol Development, *Project Update*

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PNNL OE ES Program Peer Review

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U.S. DEPARTMENT OF ENERGY BATTELLE

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2nd Life Test Protocol Development Objective & Description

Project Title

EV/Hybrid Battery 2nd Life Test Protocol Development

Objective

This project will develop a test protocol to re-qualify and re-rate retired mobile battery modules. A sample of retired hybrid bus battery modules will be re-rated to validate the protocol. This project will inform King County Metro (KCM) and their industry peers on the feasibility, cost, and potential economic net benefits from re-using retired mobile battery packs in stationary energy storage applications and delaying ultimate disposal at a cost (today's practice), or recycling.

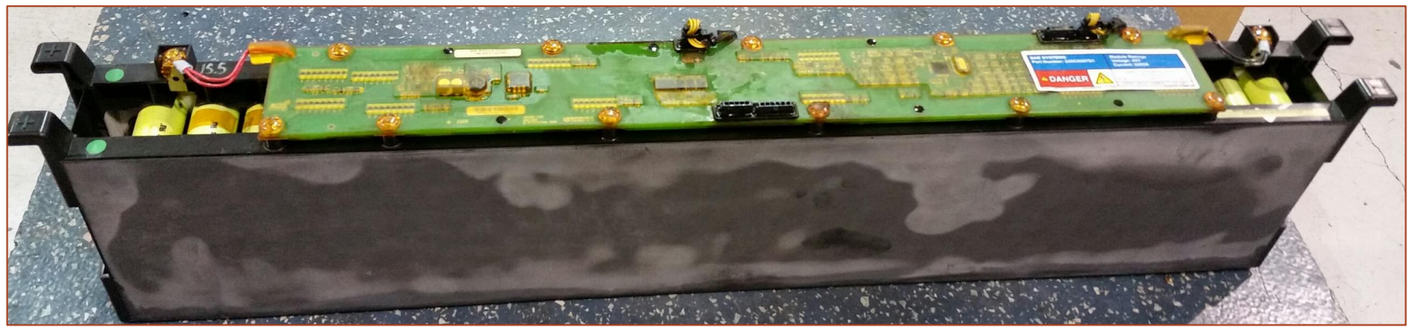
Description

KCM will provide retired bus battery modules and their associated operating history. PNNL will use these modules to develop a test protocol for re-rating retired mobile battery modules. Re-rated modules can be integrated into a small-scale Battery Energy Storage System (BESS) to demonstrate a stationary ES providing peak demand reduction.

2nd Life Test Protocol Development Key Outcomes

- Develop and validate a test protocol to requalify and re-rate retired mobile battery modules from King County Metro in Seattle

- Provide a basis for follow-on R&D to demonstrate "2nd Life" use of retired mobile batteries in stationary ES applications, using 20 kWh battery pack comprised of screened modules. This basis will include insights on technical difficulty and costs to integrate KCM's 'negative cost' 2nd Life modules into an ESS.



Photos provided by King County Metro, Seattle

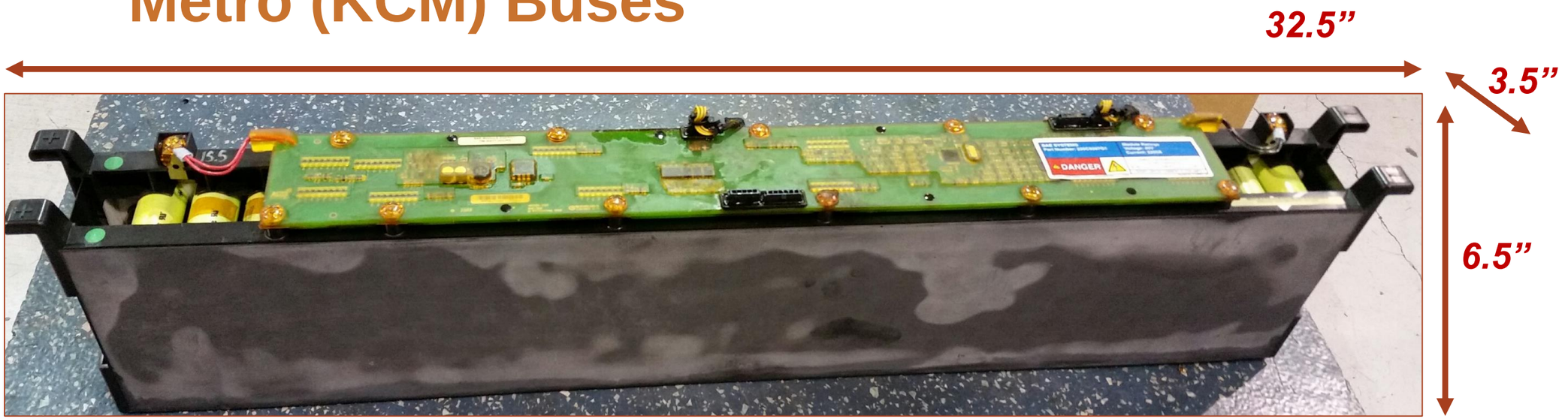
2nd Life Test Protocol Development, Scope

Major Scope Item	Task Lead, *Status*
1. Design and implement Lab upgrades needed for 2nd Life testing.	PNNL ***Active***
2. Develop 2nd Life re-rating test protocol and testing infrastructure at PNNL's ES Reliability Lab.	PNNL ***Pending FY22***
3. KCM loan PNNL an initial 50kWh of retired bus battery modules and associated data. Execute 2nd Life re-rating test protocol development and validation.	KCM, PNNL ***Pending FY22***
4. PNNL return re-rated batteries to KCM, and issue report that documents 2nd Life test safety design, test protocol, and initial re-rating test results	PNNL, KCM ***Future***

2nd Life Test Protocol Development, Schedule

Milestone	Planned Date	Mo's from DoE Approval
Initial Clean Energy Fund proposal	11/13/2018	
DOE OE ES Decision (approved for FY2020 AoP)	7/2019	0
PNNL 2nd Life Hazard Analysis completed Related safety analysis, e.g. FMEA for lab testing used batteries	8/2020	14
PNNL start 2nd Life testing lab upgrade design.	10/2020	16
PNNL complete 2nd Life testing lab upgrades. KCM start delivery of used modules & related operational data to lab.	12/2021	29
PNNL start lab battery testing.	1/2022	30
PNNL complete testing of initial 50kWh of used batteries. PNNL returns batteries to KCM. 25kWh 'net' re-rated assumed available for 2nd Life demo, from 50kWh tested.	12/2022	39
PNNL complete report on re-rating test protocol, and initial test results, and results of econ. screening analysis of 2nd Life application (peak shifting) at a KCM facility	1/2023	40

Hybrid Bus Battery Modules – From Retired Battery Packs Previously Used in King County Metro (KCM) Buses



- Modules from KCM’s Hybrid Bus Fleet,
  >MWh of capacity already retired
- 2nd Generation BAE Hybrid Bus Packs
- Battery Modules manufactured by A123 Systems
- Orig.(New) Rating was 0.7kWh each
- Target Re-Rating is 0.5kWh each, with target 13 years of 2nd Life use
- Approx. 100 used modules to be tested by PNNL for re-rating, then returned to KCM

Accomplishments, FY20-21

- Hazard analysis completed, selected highlights follow
- 2nd Life test facility design complete. Construction Active

Second Life Battery Testing

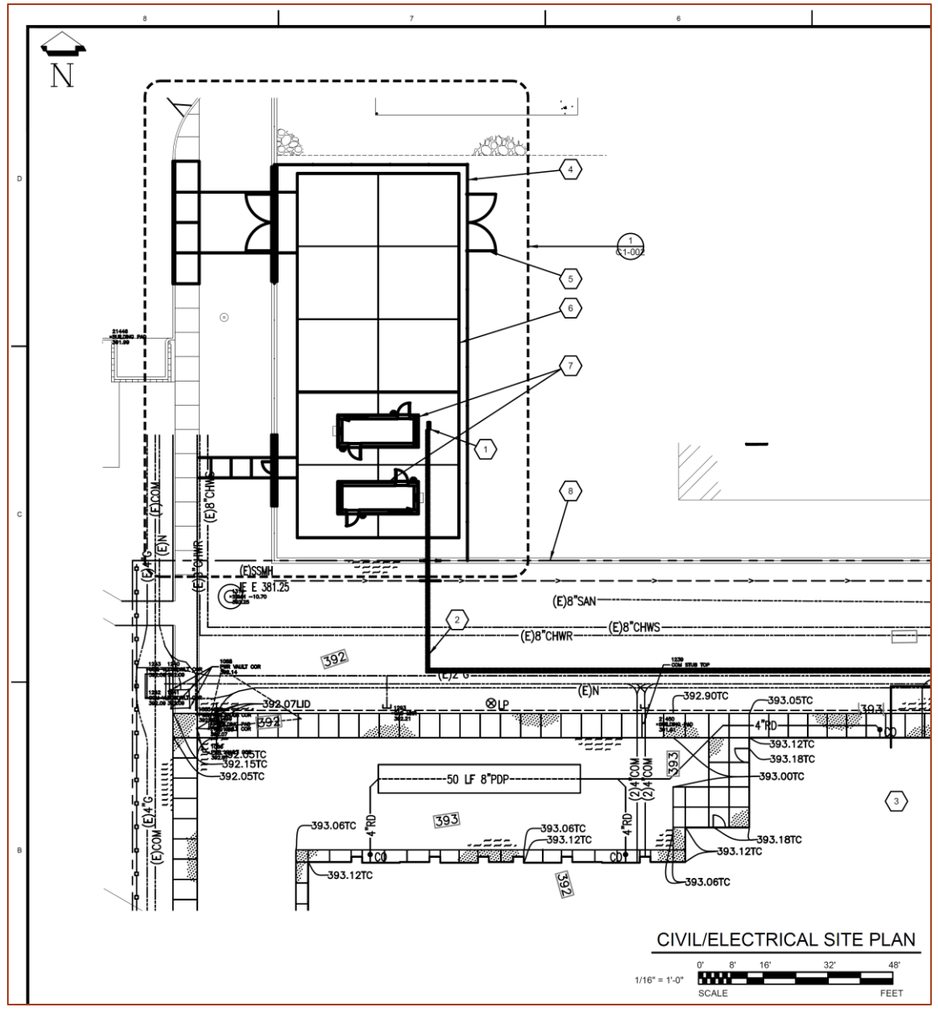
RAL SYMBOLS LEGEND

20A, 120V, DUPLEX RECEPTACLE (SURFACE-MOUNT)
20A, 120V, DUPLEX RECEPTACLE, UNDER FLOOR
30A, 208V, L6-30R, RECEPTACLE,

PROJECT INFORMATION

PROJECT DESCRIPTION:
2ND LIFE BATTERY TESTING

PROJECT ADDRESS:
??? HORN RAPIDS ROAD, RICHLAND, WA 99352

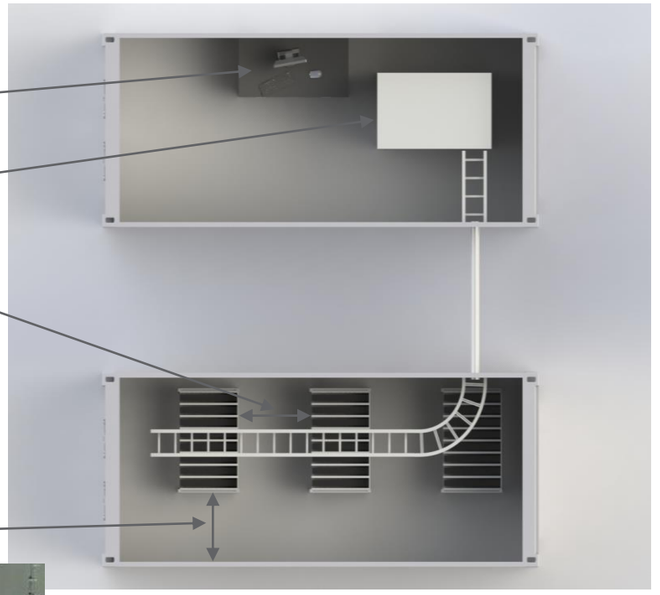


Hazard Risks Identified and Safety Mitigation Options Evaluated

- DC Arc Flash During Module Installation
- Thermal Runaway Caused by Internal Fault or Mis-Operation
- Thermal Runaway Caused by External Exposure
- Handling Accident During Shipping or Receiving

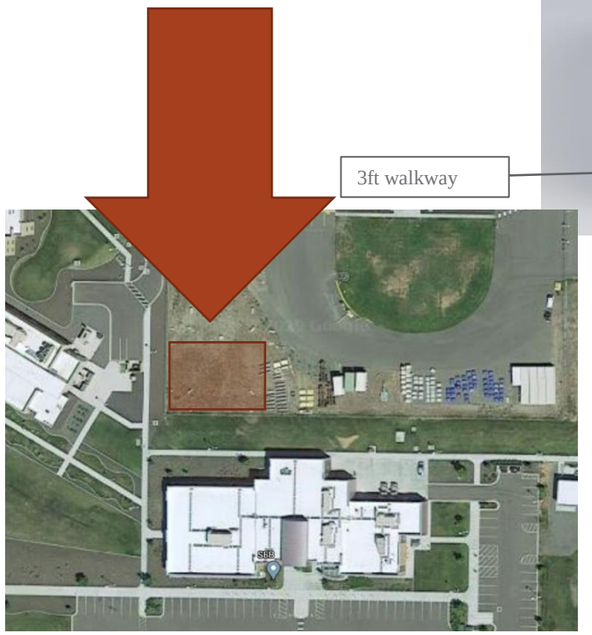
Safety Risk Management Approach

- Scope: Battery Module Qualification
  - No abusive testing
  - No interconnections between modules
  - No assembly into BESS
  - 24 modules under test, 17kWh total capacity



- Hazard ID checklist
  - Screening for standard industrial hazards

- Formal evaluation of significant hazards
  - Informed by GSL HA



Next Steps, FY22-FY23

- 2nd Life Test Facility construction
- 2nd Life Test Facility commissioning
- 2nd Life Test Protocol development
- 2nd Life Test Protocol applied and refined on KCM-loaned used modules
- Re-rated modules returned to KCM, and available for integration into BESS for demonstration at KCM
- Project report completed

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Acknowledgement

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Thank you

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